LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

SURFACE CATCHES OF MARINE DIATOMS AND DINOFLAGELLATES MADE BY U.S.S. "PIONEER" IN ALASKAN WATERS IN 1924

BY

WINFRED EMORY ALLEN

BULLETIN OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY
LA JOLLA, CALIFORNIA

TECHNICAL SERIES, Volume 2, No. 2, pp. 139–153, 2 figures in text

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY, CALIFORNIA
1929

The SCRIPPS INSTITUTION OF OCEANOGRAPHY, LA JOLLA, CALIFORNIA, announces the beginning of a new series of its **Bulletin**—the **Technical Series.** The following numbers have been issued. Other numbers are in preparation.

Earlier papers from the Institution have appeared as **Bulletins of the Scripps Institution for Biological Research,** and as contributions to the series, **University of California Publications in Zoology.**

BULLETIN OF THE SCRIPPS INSTITUTION OF OCEANOGRAPHY, TECHNICAL SERIES.—Edited by T. Wayland Vaughan, F. B. Sumner, and G. F. McEwen.

Volume 1. 1927–

1. Effect of Tidal Changes on Physical, Chemical, and Biological Conditions in the Sea Water of the San Diego Region, by Erik G. Moberg and Winfred Emory Allen. March, 1927 ..... .25
2. Quantitative Studies on Inshore Marine Diatoms and Dinoflagellates of Southern California in 1921, by Winfred Emory Allen.
3. *Idem,* 1922.
   Nos. 2 and 3 in one cover. March, 1927 ..... .25
4. Surface Catches of Marine Diatoms and Dinoflagellates made by U.S.S. "Pioneer" in Alaskan Waters in 1923, by Winfred Emory Allen. March, 1927 ..... .25
5. Studies on Marine Diatoms and Dinoflagellates Caught with the Kofoid Bucket in 1923, by Henry P. Dorman. March, 1927 ..... .25
6. Notes on Cestodes and Trematodes of Marine Fishes of Southern California, by George F. Sleggs. March, 1927 ..... .25
7. Quantitative Studies on Marine Diatoms and Dinoflagellates at Four Inshore Stations on the Coast of California in 1923, by Henry P. Dorman.
8. Pelagic Fish Eggs off La Jolla, California, by P. S. Barnhart.
   Nos. 7 and 8 in one cover. March, 1927 ..... .25
9. Marine Phytoplankton in the Region of La Jolla, California, during the Summer of 1924, by George F. Sleggs. March, 1927 ..... .30
10. Recent Foraminifera from Off the West Coast of America, by Joseph A. Cushman. September, 1927 ..... .90
11. Surface Catches of Marine Diatoms and Dinoflagellates off the Coast of Oregon by U.S.S. "Guide" in 1924, by Ralph Lewis. November, 1927 ..... .25
12. Surface Catches of Marine Diatoms and Dinoflagellates from Pacific High Seas in 1925 and 1926, by Winfred Emory Allen and Ralph Lewis. November, 1927 ..... .25
13. Catches of Marine Diatoms and Dinoflagellates Taken by Boat in Southern California Waters in 1926, by Winfred Emory Allen. January, 1928 ..... .55
14. The Periodic Occurrence of Copepoda in the Marine Plankton of Two Successive Years at La Jolla, California, by C. O. Esterly. March, 1928 ..... 1.25
15. Quantitative Studies on Inshore Marine Diatoms and Dinoflagellates Collected in Southern California in 1924, by Winfred Emory Allen. November, 1928 ..... .25

SURFACE CATCHES OF MARINE DIATOMS AND DINOFLAGELLATES MADE BY U. S. S. "PIONEER" IN ALASKAN WATERS IN 1924

BY

WINFRED EMORY ALLEN

Bulletin of the Scripps Institution of Oceanography
of the University of California
La Jolla, California

Technical Series, Volume 2, No. 2, pp. 139–153, 2 figures in text
Issued June 13, 1929

University of California Press
Berkeley, California

Cambridge University Press
London, England

SURFACE CATCHES OF MARINE DIATOMS AND DINOFLAGELLATES MADE BY U. S. S. "PIONEER" IN ALASKAN WATERS IN 1924

BY
WINFRED EMORY ALLEN

CONTENTS

PAGE
Locality and methods 139
Route sections 140
General discussion 141
Dinoflagellates 143
Diatoms 143
Catches in section 5 in 1925 147
Latitude 148
Topography 148
Temperature 148
Salinity 149
The problem of decisive factors 150
Summary 152
Literature cited 153

LOCALITY AND METHODS

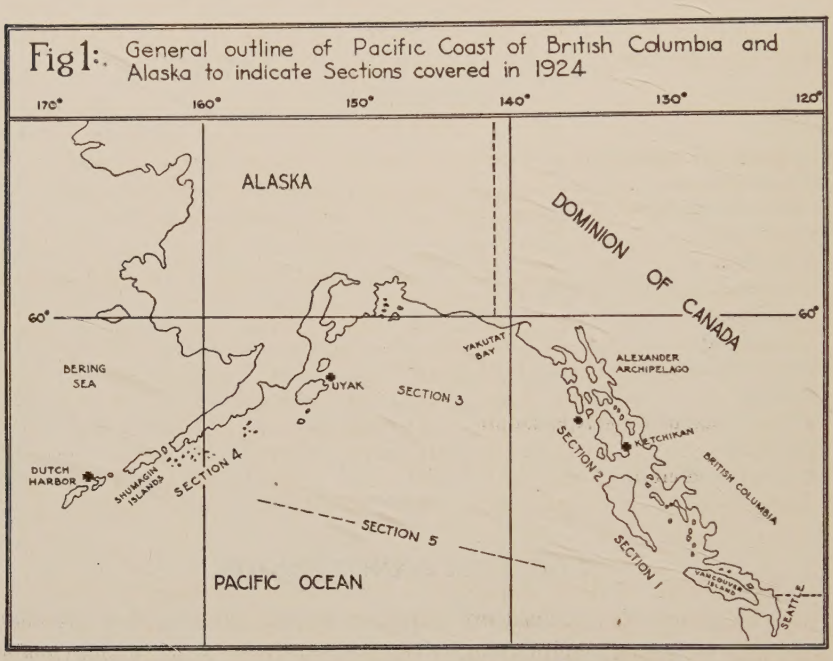
The series of catches on which this report is based was collected in the Northeast Pacific Ocean by the United States Coast and Geodetic Survey Steamer "Pioneer" by the same methods and over part of the same areas as those used and covered by the "Pioneer" in 1923 (Allen, 1927). The main difference in route consisted in running from Cape Ommaney across the Gulf of Alaska to Marmot Bay (near Kodiak Island) instead of going up through the Alexander Archipelago to Cape Spencer and then following the shores of the gulf from Cape Spencer to Kodiak Island as was done in 1923.

Concurrently with the plankton catches, temperatures at the surface were recorded, and surface samples of water were preserved to be later examined for salinity determinations at the Scripps Institution of Oceanography.

ROUTE SECTIONS

As in the report for 1923 (Allen, 1927) the route sections have been arbitrarily designated according to convenience, sections 1, 4, and 5 remaining approximately the same (fig. 1).

1. Seattle to Ketchikan, through the straits east of Vancouver Island, Princess Royal Island, Banks Island, and others of like situation.



2. Ketchikan through Clarence and Sumner straits to Cape Ommaney. (This is approximately the southern third of section 2 of the 1923 report.)
3. Cape Ommaney directly across the Gulf of Alaska to Marmot Bay entrance (near Kodiak Island).
4. Aleutian Island section. From Marmot Bay to Dutch Harbor and return to Shumagin Islands (somewhat irregular in time and direction).
5. Unimak Island directly across North Pacific to region of Vancouver Island and through Strait of Juan de Fuca to Seattle.

GENERAL DISCUSSION

The total number of catches taken in the five sections was 235, all from the surface level. In the first three sections these were taken at hourly intervals while under way, but in the Aleutian Island section some were taken at other intervals, and in the last section two-hour intervals were the rule. The months of collecting, April in sections 1, 2, and 3; April and May in most of the Aleutian Island section (4), and August in the remainder; and September in the last section, corresponded closely with those of the 1923 series. Therefore it appears that in all essential respects the series for 1924 is fairly comparable with that for 1923.

TABLE 1

SHOWING COMPARATIVE NUMBERS OF GENERA, SPECIES, TOTAL NUMBERS OF CATCHES, AND NUMBERS OF CATCHES EXCEEDING 100,000 CELLS FOR EACH SECTION, AND FOR WHOLE SERIES, IN 1924 AND IN 1923

Section	Genera		Species		Catches		Catches over 100,000	
	1923	1924	1923	1924	1923	1924	1923	1924
1	17	23	33	47	28	55	9	12
2	21	13	43	29	27	15	17	6
3	15	17	42	32	27	21	13	0
4	17	22	44	53	33	60	13	6
5	28	22	57	49	169	78	1	0
Whole series	37	29	76	78	284	229	53	24

No catches in 1924 approached the size of the largest catches in 1923, possibly because the localities in the general region of Cape Spencer, so highly productive of diatoms in 1923, were not visited in 1924. However, there were relatively more small catches in other localities than there were in 1923 (table 1) and it may be that similar reductions would have been found there.

One point of particular interest in the general aspect of this series is that the direct run across the Gulf of Alaska from Cape Ommaney gave opportunity to compare production on the high seas with that of certain coastal areas at the season of the year generally recognized as productive. It also gave opportunity for comparison with the results of collecting in section 5 in September, farther out on the high seas. It is notable that these two sections agreed in their failure to show any catch above 100,000 cells per liter, whereas each of the other sections

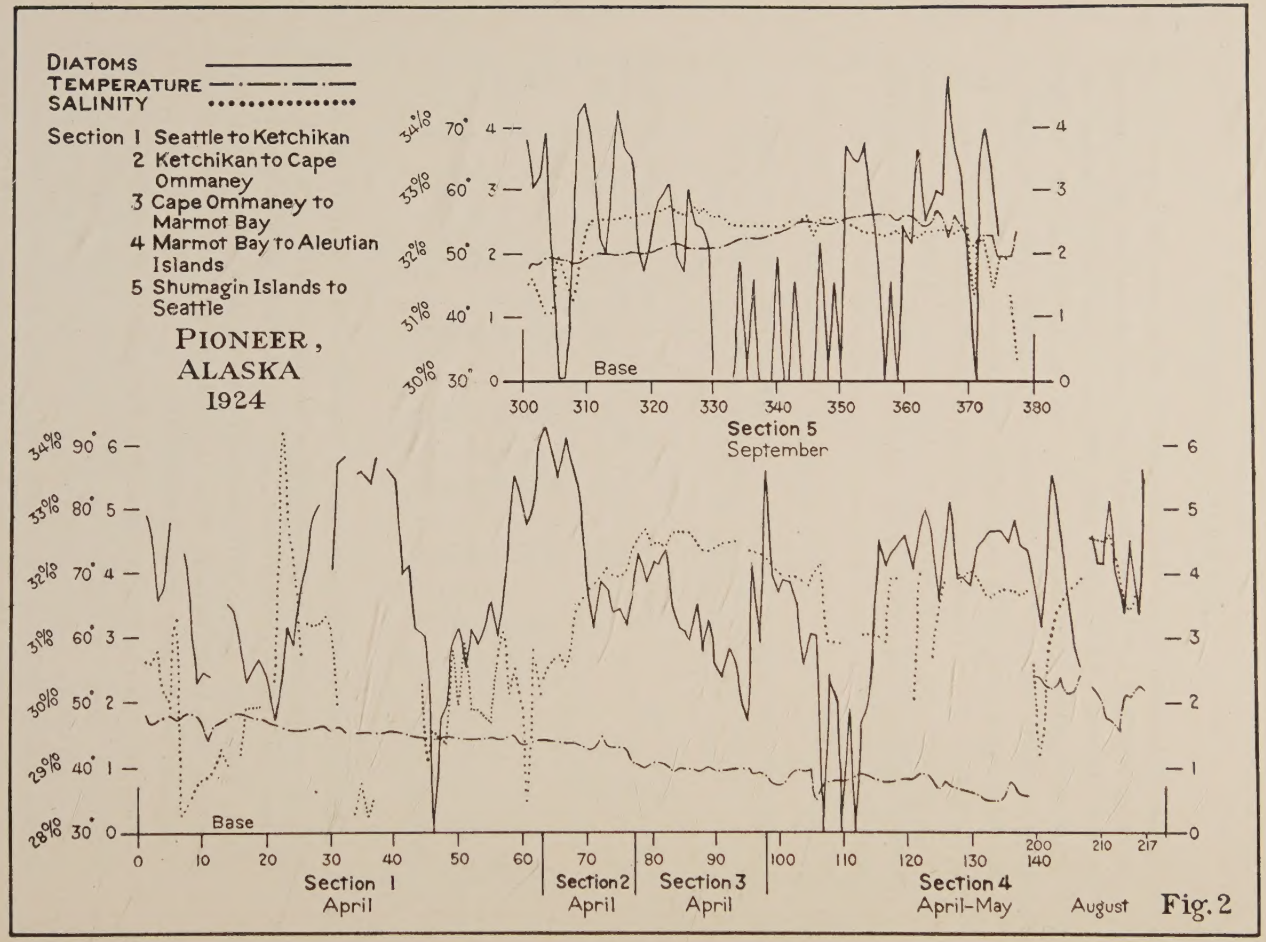

DIATOMS
TEMPERATURE
SALINITY
Section 1 Seattle to Ketchikan
2 Ketchikan to Cape Ommaney
3 Cape Ommaney to Marmot Bay
4 Marmot Bay to Aleutian Islands
5 Shumagin Islands to Seattle
PIONEER, ALASKA 1924
Base
Section 5
September
Base
Section 1
April
Section 2
April
Section 3
April
Section 4
April-May
August

Fig. 2

showed at least a few. However, the two sections differed in the fact that some diatoms were found in every catch of section 3 while none were found in several catches from section 5.

As in 1923 all sections agreed in showing distinct irregularity in numbers obtained by successive catches. Although there were a few cases in which three or four successive catches resembled one another in size, and several cases in which two successive catches were much alike, the general rule was that considerable differences occurred in a group of successive catches. Sometimes these differences were extreme (fig. 2). Thus it becomes increasingly apparent that organisms of this type are not uniformly distributed through the sea or even through relatively large areas of the sea.

No general relationship of size of catches to temperature is apparent (fig. 2), and although there was some indication of a tendency for larger catches to be taken where salinities were median or low (within the ranges observed in this series), several moderately large catches were taken where salinity was rather high.

The highest latitude reached in this series was about 58° N (approximately the latitude of the largest catches of 1923), but the largest catches were taken near 55° N. As in 1923, the locality showing greatest abundance was at a latitude about three degrees lower than the highest at which catches were taken, showing that abundance does not necessarily increase with higher latitude.

DINOFLAGELLATES

Dinoflagellates were very poorly represented in all sections of the series. In fact, only four catches in the entire series exceeded 500 cells per liter and most of the individuals in these were too small and ill defined for species identification. For more than half of the catches in each of the first four sections and for about half of the catches in the last section no dinoflagellates were listed at all. Seven genera and twenty species were noted, distributed very irregularly throughout the series. On the basis of their showing in both 1924 and 1923 the dinoflagellates deserve a negligible rating in the plankton population of Alaskan waters. For that reason further discussion is deferred.

DIATOMS

Forty-seven species of diatoms representing twenty-three genera were listed for the section between Seattle and Ketchikan (table 1). These numbers are more than 30 per cent larger than those for 1923, probably because catches were taken with much greater frequency and

reached a higher total. The larger number of catches yielding more than 100,000 cells per liter is doubtless to be explained in the same way. The probability of this explanation must be rather high inasmuch as the productivity of the 1924 series seems to have been less than that for 1923 (as noted in general discussion preceding). As in 1923, catches were mostly small or very light for a long distance north from Seattle, much farther in 1924 than in 1923, none of notable size being taken until about the middle of Queen Charlotte Strait near the north part of Vancouver Island (119, 451 per liter). The next catch of good size (561, 425) was made a little northwest of Cape Caution and it was followed by a succession of seven others of comparable size obtained from the narrow channels east of Calvert, Hunter, and Denny islands, to the north of Denny and Campbell islands, and near the southern end of Princess Royal Island. In most of these catches *Skeletonema costatum* (Grev.) and *Chaetoceras debile* Cl. were far in the lead in numbers but *Thalassiosira decipiens* (Grun.) and some other species of that genus were prominent at times. This representation of species and genera agrees well with that of 1923 (Allen, 1927) in the same general region. The seventeen catches next succeeding this group were all light, one in the narrow channel on the east side of Princess Royal Island near the north end showing no diatoms at all and several near it showing less than 1000 cells per liter. This large group of small and very small catches was in the general region of the Skeena River, a region showing similarly small numbers in 1923. Mention of the river naturally suggests lower salinity as an explanation for these small numbers, but as a matter of fact some of the preceding group of large catches were made where salinity was lower than at the point of the poorest catch in this group (fig. 2, cf. catches 34–37 with catch 46). In Revillagigedo Channel, near Mary Island (somewhat northeast of Duke Island and near where a large catch was obtained in 1923) a larger catch was again found which was succeeded by two others between that point and Ketchikan, all three exceeding 100,000 cells per liter. The leading components of these larger catches were partly different from those of that general locality in 1923, *Nitzschia seriata* Cl. being first in one catch and *Chaetoceras debile* Cl. first in both of the others. As before, *Thalassiosira nordenskioldii* Cl. was conspicuous, but *Skeletonema costatum* (Grev.), the leader in the largest catch of 1923 in that locality, was not very abundant.

Twenty-nine species representing thirteen genera (table 1) were listed in the section between Ketchikan and Cape Ommaney. The first six catches after leaving Ketchikan were fairly large but the other nine were all small, most of them very small. The large catches were

all taken in Tongass Narrows and Clarence Strait where catches of similar size were made in 1923. There was marked difference in the components, however, *Thalassiosira nordenskioldii* Cl. holding a commanding lead where, in the preceding year, it had been completely overshadowed by *Chaetoceras debile* Cl. and other forms of that genus. Among the islands north of Clarence Strait, through Sumner Strait, and thence to Cape Ommaney, the very small size of the catches closely resembled that condition in 1923.

Thirty-two species representing seventeen genera were found in the section across the Gulf of Alaska from Cape Ommaney to Marmot Bay entrance. Only one catch (in mid-gulf about one hundred and twenty miles southwest of Cape St. Elias) reached a total of 25,000 diatom cells per liter, mostly *Chaetoceras debile* Cl., *Nitzschia seriata* Cl., and *Thalassiosira subtilis* (Ostf.). The other catches were all much smaller and the representation for each species was poor. Rough weather prevented taking collections until far toward the middle of the gulf from Cape Ommaney, somewhat more than two hundred miles in fact. On the showing of catches actually made (fig. 2) the general trend was toward smaller numbers from mid-gulf westward. This is contrary to indications from other series that catches tend to increase in size as land is approached. But, so far as we know in this case, the trend may have been toward lower catches from Cape Ommaney westward, the seemingly larger catches of mid-gulf being actually median to still larger numbers of uncaught organisms farther east. At any rate, it is important to note that numbers of diatoms as great as 25,000 cells per liter were observed in mid-gulf. Under favorable conditions this number might be increased easily to more than 100,000 per liter in the next forty-eight hours, thus rising quickly to fairly good productivity. This kind of increase may have occurred in that locality a little earlier or a little later, and, so far as our records show, the whole gulf may have shown fairly large, or large, numbers at some part of the season. Twenty-five thousand is a small catch when there is continuity of observation to prove it representative but when it represents but a single moment in a transient series it must be regarded as suggesting large possibilities. Most of the catches in the western part of the gulf gave totals of less than 1000 cells per liter. A rather striking exception occurred in the next to last catch before reaching Marmot Bay which showed over 18,000, nearly all being *Chaetoceras debile* Cl.

By including in section 3 only those catches well offshore and outside of headlands it was possible to discuss it as a strictly oceanic section. For that reason the catch taken within Marmot Bay, just north of Spruce Island and Kodiak Island, was included in section 4,

the topography of which has resemblance to part of section 1 in that there are straits, narrows, and passes to be traversed and broken coast lines to be skirted. Most of the sixty catches of section 4 were taken within twenty miles of land, many of them only short distances from shore. In the main, therefore, this section may be regarded as neritic rather than oceanic in character. Fifty-three species of diatoms representing twenty-two genera were noted. Only six catches exceeded 100,000 cells per liter, less than half the number of 1923 out of almost twice as many catches as were taken in that year. Three of these were taken in April, one from Marmot Bay and two from the Shumagin Islands. The other three were taken in the last half of August, one near the end of Alaska Peninsula and two near Unimak Island. The fairly large catch (399,776 cells per liter, mostly *Chaetoceras debile* Cl.) in Marmot Bay has peculiar interest because it was far larger than any catches anywhere near Kodiak Island in 1923, a condition directly contrary to the general indication just mentioned that abundance was generally lower in section 4. The two catches of notable size near the Shumagin Islands in 1924 were to the east of the group instead of to the west as they were a month later in the preceding year. Of the other three, all were near localities of fairly large catches in 1923; the one off the Alaska Peninsula (near Deer Island) was very close to the locality of a much larger catch in 1923, the one near Cape Pankof was considerably larger than any other in that locality, and the one north of Akun Island was much smaller than two in its locality in June of the preceding year (two months earlier). The two months' difference in time of year may have had important bearing on these last differences. Certainly it prevents definite comparison of abundance in these localities in the two years. This is also true in the matter of species represented, *Chaetoceras debile* Cl. being inconspicuous in the general region of the Shumagin Islands where it had a distinct lead a month later in the season of 1923, and *Skeletonema costatum* (Grev.) taking the lead near both ends of Unimak Island where it was inconspicuous in 1923.

The catches in section 5 (from Shumagin Islands across the open ocean to Seattle) in September were much fewer (78) than they were over the same course in October, 1923 (169). Not one reached a total of 100,000 cells per liter and only five showed totals of more than 10,000 cells per liter. Three of these five were forty to one hundred miles south and southwest of Chilikoff Island, another was near Port Angeles, Washington, and the fifth was about eighteen miles off Portland Point, Vancouver Island. The differences shown between the sizes of catches far offshore and those near Vancouver Island were not so great as in the preceding year but the differences were similar

in that most of the extremely small catches, or catches yielding nothing, were in mid-ocean (fig. 2). No species showed striking prominence for the series as a whole although *Chaetoceras debile* Cl. and *Nitzschia seriata* Cl. were fairly notable both for frequency and abundance. *Thalassiosira decipiens* (Grun.) and *Thalassiothrix nitzschioides* (Grun.) also showed some prominence. The catches from this section agree with those of the other sections in indicating a lower general productivity of diatoms in Alaskan waters in 1924 than was shown in 1923. There was only about a week of difference in time of season in the two years, so they may be regarded as comparable in this respect.

CATCHES IN SECTION FIVE IN 1925

In 1925 the only catches by the United States Coast and Geodetic Survey in Alaskan waters were made in September in section 5 on the direct run from the Aleutian Islands to Seattle. For that reason the series can be discussed more conveniently here than in a separate report.

The series of catches for 1925 ended just outside the Strait of Juan de Fuca with a total number (158) to that point two greater than that for 1923, and more than twice as great as that for 1924. Over this comparable course distribution of abundance was closely similar in gross features to that of preceding years, the principal difference being in the size of catches and in the location of those catches of larger size. In 1925 eighteen catches were greater than 10,000 cells per liter, whereas only five exceeded that number in 1924 and only nine in 1923. These eighteen catches were all located between a point about one hundred and fifty miles west of Queen Charlotte Island and Cape Flattery, whereas more of them were located near the Shumagin Islands in 1923 and south of Chilikoff Island in 1924 than were located in the eastern part. The largest catch of the series (45,243 cells per liter) was the largest of any taken in the three years between the Shumagin Islands and Vancouver Island. It was made west of the entrance to Barkley Sound (Vancouver Island). The series of all three years, in the long stretch of mid-ocean, were alike in showing all catches low and many yielding nothing, although some catches there showed considerable numbers. No species took an outstanding lead in this section but *Chaetoceras debile* Cl. and *Nitzschia seriata* Cl. were prominent in many catches and *Skeletonema costatum* (Grev.) was a leader near the Shumagin Islands, as it had been formerly. *Chaetoceras decipiens* Cl. and *Bacteriastrum varians* Laud. were more prominent than in either of the preceding series. As in 1923 and 1924 the numbers of dinoflagellates found in this section were negligible.

LATITUDE

At the time of writing the report for the Alaska collections of 1923 (Allen, 1927), certain catches in the Alexander Archipelago and the region of Cape Spencer were so much larger than any appearing at that time on the records of the Scripps Institution of Oceanography that a provisional statement was made to the effect that there was some indication of higher productivity in higher latitudes. Since that time catches larger than any yet recorded for Alaskan waters have been obtained from the open sea off Gray's Harbor, Washington, and others taken still farther south are comparable with the largest of the Alaskan catches of 1924. Indeed, the average of daily catches for a week at Point Hueneme pier (less than one hundred miles from Los Angeles) in southern California, at about the same time that largest catches were being taken in Alaskan waters in 1924, was over 2,000,000 diatom cells per liter, greater than any single catch of the Alaskan series of that year. Obviously, therefore, even the incomplete evidence now in hand indicates that latitude alone cannot support a broad generalization as to relative productivity of localities.

TOPOGRAPHY

As in 1923, all the large catches were taken fairly close to land (thirty miles or less). This is in substantial agreement with a number of series in other regions of the East Pacific, and, so far as surface catches are concerned, one may safely conclude that great abundance of diatoms is a very rare condition in the open Pacific far from shore.

TEMPERATURE

Surface temperatures of the sea were recorded at times of plankton collecting. A fairly good understanding of the range of temperatures and of the characteristics of local differences is obtainable from the general graph (fig. 2). These features are generally similar to those of 1923 in comparable localities, showing a distinct trend to lower readings while west bound and to higher readings while east bound. The table (table 2) showing the maximum and minimum and average of the ten temperatures in each section accompanying the ten largest and the ten smallest catches agrees with that for 1923 in showing large catches in about the same range of temperatures as is found with smallest catches. This similarity of ranges would appear still closer if the table had been constructed for catches above and below

certain limits of numbers because that arrangement would have eliminated some catches rated with the ten largest which were rather small themselves. (The extremes for catches above 100,000 diatom cells per liter were 37° F and 52° F and the average 44.6° F.) This was especially true of the Aleutian Island section (4) in which confusion appeared on account of some catches being taken in April and May and others in August. However, the main feature of the table seems to be clear, i.e., that great abundance may be found in a very wide range of temperatures. In other words, the information now available does not lend encouragement toward attempts to identify any certain temperature as optimum for abundant production of diatoms at the surface level in waters of the Northeast Pacific.

TABLE 2

TEMPERATURES WITH SELECTED CATCHES

Section	Temperature (F) ten largest catches			Temperature (F) ten smallest catches		
	Highest	Lowest	Average	Highest	Lowest	Average
1	46°	45°	45.3°	48°	44°	45.7°
2	45°	42.5°	43.65°	45°	42.5°	43.2°
3	40.8°	39°	40.2°	40°	39.5°	39.9°
4	54°	35°	43.2°	54°	38°	39.9°
5	57.5°	47°	51.6°	56°	49°	53.3°

SALINITY

With the plankton collections of 1924, water samples were taken from which salinity determinations were made afterward in the hydrographic laboratory of the Scripps Institution of Oceanography. As might be expected in a region of heavy drainage from land, the higher salinities were generally found offshore and the lower inshore (although the highest recorded was from Johnstone Strait near the northeast shore of Vancouver Island in a relationship showing it clearly abnormal to the series, whether due to a narrowly localized condition or to failure in preservation). There was a considerable variability in the catches near shore (fig. 2) caused probably by differences in amount of rainfall or by location with reference to streams or currents of relatively fresh water at times of sampling.

Of salinities, as of temperature, it may be noted that the differences in abundance of diatoms had no visible relationship to differences in the observed physical condition. According to table 3 it appears clear that in each section the range and the average for ten catches of

greatest abundance were essentially similar to those for the ten of least abundance. In the twenty-five catches reaching an abundance greater than 100,000 diatom cells to the liter the range was from $28.20^0/_{00}$ to $32.65^0/_{00}$ and the mean was $30.33^0/_{00}$, showing that considerable abundance might be found accompanying salinities ranging from one extreme to the other of the records in the table.

TABLE 3

Salinities Accompanying Selected Catches

(Recorded in parts per thousand)

Section	Salinities ten largest catches			Salinities ten lowest catches		
	Highest	Lowest	Average	Highest	Lowest	Average
1	31.23	28.20	29.60	30.71	28.68	29.58
2	31.96	30.08	30.94	32.10	30.74	31.68
3	32.74	32.32	32.48	32.67	32.30	32.46
4	32.65	31.20	31.89	32.19	31.90	32.00
5	32.56	31.06	32.06	32.61	31.43	32.29

THE PROBLEM OF DECISIVE FACTORS

Considering the leading part frequently assigned by investigators to temperature and salinity in discussing the relations of environment to biological phenomena of the sea, and considering the sharply defined operation of these influences in many biological experiments, it may appear that the wide tolerance of temperatures and the considerable tolerance of differences in salinity shown here indicates a low grade of responsiveness in these organisms and that it is not highly important to examine relationship to such factors. However, I do not believe that this interpretation of appearances is tenable.

One might assume that the showing of wide tolerance in these circumstances is fictitious rather than real, since it involves the whole group of diatoms, in which may be included some species tolerant of one range of difference and some of another, whereby the group may reach abundance through single species rather than as a whole. Against this assumption an essential difficulty lies in the fact that highly productive species like *Chaetoceras debile* Cl. and *Nitzschia seriata Cl.* are known to reach abundance in ranges similar to those noted for the whole order. At any rate the range for temperature is not so great and the changes are not so abrupt as those in which many species of plants of land and shallow ponds live and thrive.

An assumption that within any designated species a race or variety may arise or be developed to meet any particular part of a range of temperature (or other condition) is tenable but it is not very helpful in understanding the conditions of existence of pelagic diatoms. Indeed, it is less confusing to suppose that requisite powers of adaptation reside in the individual representatives than it is to assume that a certain zone of a range of differences requires the origination of a new variety to fit it. It is very commonly known that many garden plants can be made highly susceptible to damage by cold by cultivation in a hothouse for a time and that they can then be made more resistant by careful and gradual change to colder conditions. There is no good reason to suppose that pelagic plants are essentially different in their capacity for extending their ranges of endurance to meet the ordinary ranges of differences in their environmental conditions.

On the other hand, it has been shown so convincingly in natural, domestic, and experimental environments that almost all observable factors have recogizable maxima, optima, and minima in respect to the welfare of many organisms that it must be admitted that all organisms may receive such ranges of influence from many or most factors. Offhand, one might suppose that an organism would reach its condition of highest welfare if every factor of the environment be optimal, but continued reflection shows this to be improbable, if not impossible. For example, a temperature shown by exclusion to be optimum under laboratory conditions may differ from the one permitting optimal solution of oxygen in natural sea water, or the optimum salinity may prevent an approach to the optimum viscosity, or the optimum of oxygen for a parasite may be far from optimum for the host upon which it depends for sustenance.

For such reasons it seems certain that under normal conditions the decisiveness of influence of any factor of the environment does not depend on its range above or below its theoretical optimum but that it does depend, at any instant, on its relation to the equilibrium of the environmental system as a whole. If the influence of the environmental system as a whole be tolerable it may be that an increase of one unit in temperature (even if that be super-optimal) will so disturb the general equilibrium (by acceleration of chemical and physical processes, etc.) that growth and development of one or more organisms may be definitely increased. Through the fundamental relations of these to others and to the whole it is quite possible that the whole system may be considerably changed before an equilibrium is again reached or approximated. But it is just as probable that the chain of disturbances may be broken near the beginning and the generally

tolerable condition sustained with more or less frequency of interruptions of similar type. This we may suppose to be the environmental situation through most of the year in many, if not most, marine localities. In the middle of the Gulf of Alaska it is probably the situation through the whole year and through indefinite periods of years.

Near Alaskan shores the generally tolerable conditions of winter may conceal cumulative distortions of certain features of the environmental whole which reach an instability of almost explosive character by early spring, when the incidence of a certain number of units of light accelerates chemical and photosynthetic processes which disrupt the environmental system and necessitate the establishment of new bases of equilibrium. In locality X it may be that approximate equilibrium of an entirely favorable environmental whole has been attained by (or retained to) early spring and that infra-optimal incidence of light suffices to start a wave of diatom productivity. In locality Y it may be that the tolerable whole has been distorted by drainage from land so that there must be delay while diffusion and readjustment takes place to a resultant favorable whole which supports an extremely rapid efflorescence under the stimulus of optimum light and abundant derivatives from land. At either X or Y, light might appear as the decisive factor although differing greatly in the unit power which made it decisive. But at locality Z light may be merely a part of the tolerable (or even favorable) environmental whole held in approximate equilibrium by lack of some chemical factor essential to increase of biological activity.

Taking the Alaskan region in general one has considerable evidence to support a conclusion that vernal efflorescence of diatoms is a function of incidence of light but there is ample ground for observing caution in designating light (or any other) as the decisive factor leading to extraordinary abundance at any particular time and place.

SUMMARY

This summary is essentially similar to that for 1923. It is repeated for the convenience of the reader and because of one or two slight changes and additions.

1. Several localities showed a high abundance of diatoms in April though the highest numbers were less than the highest of 1923.
2. Localities of low abundance were found in regions having other localities showing great abundance.

3. Most of the species of diatoms recorded have been commonly observed in other parts of the eastern Pacific.
4. The genus *Thalassiosira* held a prominence similar to that of 1923.
5. Dinflagellates were poorly represented in all catches.
6. Catches near land were generally heavier than those far from shore (cf. Allen, 1927, p. 47).
7. The influences of temperature and salinity were not exhibited in traceable ways in this series.
8. Highest latitudes failed to yield highest catches.
9. Distribution of diatoms (representative of plankton organisms in general) was distinctly irregular.
10. Leadership in abundance was confined to a few species.
11. General considerations point to the probability that decisiveness of influence in any environmental whole, in nature, is not certainly attributable to any single factor at a certain time and place although conditions in the Alaskan region indicate a great prominence of light. Tolerance for a considerable range above or below the optimum in respect to any factor (or to the environmental whole) seems to be a characteristic essential for the continued existence of marine plankton organisms.

LITERATURE CITED

ALLEN, W. E.

1927. Surface catches of marine diatoms and dinoflagellates made by U. S. S. "Pioneer" in Alaskan waters in 1923. Bull. Scripps Inst. Oceanography, Tech. Ser., 1:39–48.

16. Review of Five Years of Studies on Phytoplankton at Southern California Piers, 1920–1924 Inclusive, by Winfred Emory Allen. November, 1928 ..... .55

VOLUME 2. 1929–

1. Methods of Estimating the Significance of Differences in or Probabilities of Fluctuations Due to Random Sampling. Numerical Illustrations, Formulae, and Tables Prepared Especially for Estimating Probabilities when the Usual "Method of Least Squares" or "Normal Law of Error" May Not Apply, by George Francis McEwen. March 1929 ..... 1.70
2. Surface Catches of Marine Diatoms and Dinoflagellates made by U.S.S. "Pioneer" in Alaskan Waters in 1924, by Winfred Emory Allen. June 1929 ..... .25
3. The Food Habits of the California Sardine in Relation to the Seasonal Distribution of Microplankton, by Ralph C. Lewis. June 1929 ..... .30